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IMPROVEMENTS IN, OR RELATING TO, VDSL-MODEM

The invention concerns a method for performing power back-off in a VDSL-modem in a broadband access network including central office and VDSL modem operating in an access network on a wire of a certain length, where we have several other modems operating on wires with different lengths (shorter, longer, or the same) using for example a multicarrier system using Discrete Fourier Transforms to create and demodulate individual carriers

In a broadband access networks fiber all the way to the home is still prohibitively expensive. An attractive alternative is a combination of fiber cables feeding neighborhood Optical Network Units and last leg premises connections by existing or new copper.
One of the technologies for last leg premises is Very high rate Digital Subscriber Line, or VDSL. In simple terms, VDSL transmits high speed data over short reaches of twisted-pair copper telephone lines, with a range of speeds depending upon actual line length.

A problem in VDSL is that upstream FEXT (Far End CrossTalk) from users with short wires is very strong and can severely limit the performance for users on longer wires. The effect will be that the shorter wires will get rather high bit rates whereas the longer wires will get quite low bit rates (if any at all). In extreme cases may be no users further away than 1000m can transmit data in the upstream.

Power back-off is a way to reduce this problem and get a more even distribution of the available capacity among users

with different wire lengths. Power back-off means that modems on shorter wires reduce their transmit power in order to lower the FEXT. In this way modems on longer wire can get acceptable bit rates.

The method according to our invention is useful in any VDSL-system, no matter which duplex method or modulation method is used and is particular simple to implement in a DMT-system. The method also gives better performance (higher bit rates) than other methods, especially for thinner wires.

Embodiments of the invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 illustrates, in schematic form, a telephone acess network with network terminations (NT) with differt lenght from central office.

Figure 2 illustrates, in schematic form, an example on how the PSD will look for different wire lengths.

In order to facilitate an understanding of the present invention a glossary of terms used in the description of the present invention is provided below:

VDSL: Very high data rate Digital Subscriber Line: Modem for twisted-pair access operating at data rates from 12.9 to 52.8 Mbps with corresponding maximum reach ranging from 4500 feet to 1000 feet of 24 gauge twisted pair.

FEXT: Far End CrossTalk: the interference occurring between two signals at the end of the lines remote from the

telphone switch.

DMT: Discrete Multitone, a multicarrier system using Discrete Fourier Transforms to create and demodulate individual carriers. For passive NT configurations, DMT would use FDM for upstream multiplexing (although DMT does not preclude a TDMA multiplexing strategy).

PSD: Power spectral Density

NT: Network termination

A telecommunication access network is in a schematic form illustrated in fig 1 with central office and network termination points at different length from the central office. The invention is intended to be used in that type of access network.

This method according to the invention is a method for performing power back-off in a VDSL modem. Consider a VDSL modem operating in an access network on a wire of a certain length, where we have several other modems operating on wires with different lengths (shorter, longer, or the same). Having a target bit rate for this modem, the method determines how to distribute the power over the available frequency band to get this desired bit rate. This power distribution is made is such a way that the bit rates for the other VDSL-modems are maximized.

We shall now describe how the power/energy distribution is done using a DMT-system as example. Let Ek denote the transmit energy to be used on subcarrier number k. Aiming at a target bit rate of R bits per DMT-frame we have the following constraint on the energies E_k

$$R = \sum_{k=0}^{N-1} \log_2\left(1 + \frac{E_k}{\Gamma(n_k + Fext_k)\Gamma_M}\right) \qquad (1)$$

where n_k is the background noise on subcarrier k, $Fext_k$ is FEXT from other VDSL modems, Γ is the SNR-gap (= 9.8 dB), and Γ_m is the system margin (typically 3-6 dB). To maximize the bit rate for the other VDSL-modems the energy-loading should be done according to

$$E_k = \lambda \frac{n_k}{F_k}, \qquad (2)$$

where n_k is the background noise, λ is a constant (that is adjusted so (1) is fulfilled), and F_k is the FEXT transfer function for the wire under consideration. The FEXT transfer function is calculated as

$$F_k = K|H_k|^2 f_k^2 d, \qquad (3)$$

where H_k is the transfer function for the wire, f_k is the frequency for subcarrier k, d is the length of the wire and K is a constant (d and K are not important since they will dissappear in λ). By using equation (2) to set the energy distribution, the FEXT will be spectrally shaped as the background noise.

Another constraint that always exists is that E_k must never exceed the maximal allowable PSD-level for VDSL (PSD_{max}). With that in mind (2) can be rewritten as

$$E_k = \begin{cases} \lambda \frac{n_k}{F_k} & \text{if } \lambda \frac{n_k}{F_k} < PSD_{max} \\ PSD_{max} & \text{if } \lambda \frac{n_k}{F_k} \geq PSD_{max} \end{cases}$$

If a too large R is chosen it can happen then $E_k = PSD_{max}$ for all k and still the target bit rate R is not achieved. Figure 2 shows an example on how the PSD will look for different wire lengths. Shorter wires use lower transmit power in general, and tend to load more power on the higher frequencies than on the lower frequencies. Since the longer

wires only can use the lower frequencies it seems intuitive to let the shorter wires use the higher frequencies and save the lower frequencies for the longer wires.

CLAIMS

1 A method for performing power back-off in a VDSL-modem in a broadband access network including central office and VDSL modem operating in an access network on a wire of a certain length, where we have several other modems operating on wires with different lengths (shorter, longer, or the same) using for example a multicarrier system using Discrete Fourier Transforms to create and demodulate individual carriers characterised in that a special algorithm is used which can set target bit rates for the users and optimize thereafter and so lowering the interference occurring between two signals at the end of the lines remote from the central office.

Fig 1.

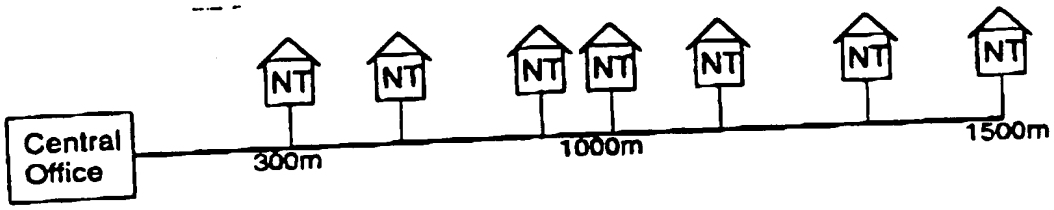

Fig 2.